1. (d). The sixty subjects are expected to be evenly distributed across the 3 brands; 60/3 = 20 subjects are expected to choose each one.

2. $df = 2$. There are 3 response categories, so there are $3 - 1 = 2$ df.

3. 75 support, 25 not support. The null hypothesis is defined by the politician's claim; 75% of 100 voters is 75, so that is how many are expected to support the policy.

4. If the psychic is just guessing, then a correct response is expected on 1/5 or .20 of the trials. The expected number of correct responses is $20(100) = 20$ and the expected number of incorrect responses is $.80(100) = 80$. The observed number correct and incorrect were 26 and 74.

   $\chi^2(1) = \frac{(26 - 20)^2}{20} + \frac{(74 - 80)^2}{80} = 2.25$

   with $\alpha = .05$, critical $\chi^2(1) = 3.84$; do not reject null hypothesis – there is no evidence for psychic ability.

   For 400 trials and 104 (i.e., 26%) correct, we have

   $\chi^2(1) = \frac{(104 - 80)^2}{80} + \frac{(296 - 320)^2}{320} = 9.00$

   with $\alpha = .05$, critical $\chi^2(1) = 3.84$; the null hypothesis is rejected and the psychic appears to have special powers.

5. The relevant $\chi^2$ test is the test of independence. The question here is whether fertilization success rate is related to or independent of exposure to the humorous performance. There are two response categories into which a subject may be placed: pregnancy achieved or pregnancy not achieved. The $df$ for this study is computed as $(R-1)(C-1) = (2-1)(2-1) = 1$. The critical value with $\alpha = .05$ would be $\chi^2(1) = 3.84$.

6. Assuming a population in an equal number of births occur in each month, if we sample from that population 56 people who were born either in the first three or last three months of the year, then we should expect an equal number to have been born within each of these two 3-month periods. So the expected frequencies are just $\frac{1}{2}$ in the first three months and $\frac{1}{2}$ in the last three months, or 28 in each 3-month period. A goodness of fit $\chi^2$ test is relevant here.

   $\chi^2(1) = \frac{(52 - 28)^2}{28} + \frac{(4 - 28)^2}{28} = 41.14$

   With $\alpha = .01$, critical $\chi^2(1) = 6.63$; reject the null hypothesis – elite soccer players are more likely to be born in the first three months of the year than in the last three months.

   The researcher offered a number of speculations for this effect, but the most reasonable is that age-group soccer for children is based on when during the year a child is born, with January 1 as a typical cutoff for an age group. Thus, children born early in a year are the
older ones in their age group and children born later in the year are the younger ones in their age group. The older children in an age group are likely to be physically bigger and stronger and therefore are more likely to be chosen for the best soccer leagues, opening more opportunities for better training.

7. This is to be a goodness of fit test in which the expected frequencies are equal across all four response categories: 50/4 = 12.5 in each category.

\[ \chi^2(1) = \frac{(18 - 12.5)^2}{12.5} + \frac{(17 - 12.5)^2}{12.5} + \frac{(7 - 12.5)^2}{12.5} + \frac{(8 - 12.5)^2}{12.5} = 8.08 \]

With \( \alpha = .05 \), critical \( \chi^2(3) = 7.82 \); reject the null hypothesis. The observed frequencies indicate that people prefer the original top or bottom to be treated as the top of the painting.

8. The sample consists of 300+80+100+40+80 = 600 people. The racial percentages in the community are the basis for the expected frequencies in this sample of 600 people. Given the community percentages, the expected frequencies for a sample of 600 people are: 288 whites, 72 African Americans, 108 Latinos, 54 Asians, and 78 others.

\[ \chi^2(4) = \frac{(300 - 288)^2}{288} + \frac{(72 - 90)^2}{72} + \frac{(100 - 108)^2}{108} + \frac{(54 - 40)^2}{54} + \frac{(78 - 80)^2}{78} = 5.66 \]

With \( \alpha = .05 \), critical \( \chi^2(4) = 9.49 \); do not reject the null hypothesis – the data do not indicate that the distribution of races in the sample is different from the distribution in the community.

9. Row and Column totals and grand total are in bold and are used in computing expected frequencies.

<table>
<thead>
<tr>
<th></th>
<th>Large city</th>
<th>Small town</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consent</td>
<td>21</td>
<td>22</td>
</tr>
<tr>
<td>Did not consent</td>
<td>31</td>
<td>10</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>52</strong></td>
<td><strong>32</strong></td>
</tr>
</tbody>
</table>

(a) Expected frequencies

<table>
<thead>
<tr>
<th></th>
<th>Large city</th>
<th>Small town</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consent</td>
<td>26.6</td>
<td>16.4</td>
</tr>
<tr>
<td>Did not consent</td>
<td>25.4</td>
<td>15.6</td>
</tr>
</tbody>
</table>

(b) \[
\chi^2 = \frac{(21 - 26.6)^2}{26.6} + \frac{(22 - 16.4)^2}{16.4} + \frac{(31 - 25.4)^2}{25.4} + \frac{(10 - 15.6)^2}{15.6} = 6.34
\]

With \( \alpha = .05 \), critical \( \chi^2(1) = 3.84 \); reject the null hypothesis.

(c) Small town residents are more likely to help.
10. Observed and expected frequencies:

<table>
<thead>
<tr>
<th>Country</th>
<th>Defect</th>
<th>Cooperate</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>31</td>
<td>36</td>
<td>67</td>
</tr>
<tr>
<td>U.S.</td>
<td>41</td>
<td>14</td>
<td>55</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>72</strong></td>
<td><strong>50</strong></td>
<td><strong>122</strong></td>
</tr>
</tbody>
</table>

\[
\chi^2 = \frac{(31-39.5)^2}{39.5} + \frac{(41-32.5)^2}{32.5} + \frac{(36-27.5)^2}{27.5} + \frac{(14-22.5)^2}{22.5} = 9.89
\]

With \( \alpha = .05 \), critical \( \chi^2(1) = 3.84 \); reject the null hypothesis. The researcher's hypothesis that cooperation rate would be higher among Chinese subjects is correct.

11. (a) The theory versus method comparison calls for a goodness-of-fit \( \chi^2 \) test where we can collapse across science discipline because that factor does not matter for the present question. We see that a total of 2+4+8 = 14 prizes were based on theory and a total of 21+22+20 = 63 were based on method. According to the null hypothesis that prizes are equally likely to be awarded for theory or method, the expected frequencies for each would be \( \frac{1}{2} \) of the total, 14+63 = 77, or 38.5. So we have

\[
\chi^2 = \frac{(14-38.5)^2}{38.5} + \frac{(63-38.5)^2}{38.5} = 31.18
\]

With \( \alpha = .05 \), critical \( \chi^2(1) = 3.84 \); reject the null hypothesis. Prizes are much more frequently given for method than for theory.

(b) To test whether the bias in favor of method holds equally across all three science disciplines, a \( \chi^2 \) test of independence is needed. The expected frequencies are computed from the row and column totals yielding the following:

<table>
<thead>
<tr>
<th>Observed frequencies</th>
<th>Expected frequencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medicine</td>
<td>Chemistry</td>
</tr>
<tr>
<td>Theory</td>
<td>2</td>
</tr>
<tr>
<td>Method</td>
<td>21</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>23</strong></td>
</tr>
</tbody>
</table>

\[
\chi^2 = \frac{(2-4.2)^2}{4.2} + \frac{(4-4.7)^2}{4.7} + \frac{(8-5.1)^2}{5.1} + \frac{(21-18.8)^2}{18.8} + \frac{(22-21.3)^2}{21.3} + \frac{(20-22.9)^2}{22.9} = 3.55
\]

With \( \alpha = .05 \), critical \( \chi^2(2) = 5.99 \); do not reject the null hypothesis. There is no evidence that the bias in awarding prizes for method rather than for theory varies across scientific discipline. Note that this test is somewhat suspect, given that for two of the cells the expected frequency is less than 5.

12. For question 7, we are using a goodness-of-fit version of the \( \chi^2 \) test. The null hypothesis is that all four orientations are equally likely to be preferred by a given person, so the proportions of observations expected in the four conditions would be .25, .25, .25, and .25. To set up the \( \chi^2 \) test in R, we specify a set of observed values in one data variable and a set of expected proportions in another:
> obs = c(18, 17, 7, 8)
> pred = c(.25, .25, .25, .25)

Finally, the chisq.test function can be applied to these two variables:

> chisq.test(obs, correct = FALSE, p = pred)

    Chi-squared test for given probabilities

data:  obs
X-squared = 8.08, df = 3, p-value = 0.04439

This result confirms our finding in question 7 that the null hypothesis can be rejected.

For question 9, we have a test of independence. To set this up, the observed frequencies are put into a variable as a matrix representing the two variables being tested. In question 9, the variables are town size (large, small) and consent (given, not given). To set up the observed values in a 2 x 2 matrix in R, we can use the matrix command:

> data = matrix(c(21,22,31,10), nrow = 2, ncol = 2, byrow = TRUE, dimnames = list(c("Consent", "Not consent"), c("Large", "Small")))

Check to make sure the result is what we expect:

> data

            Large Small
Consent      21    22
Not consent  31    10

And now apply the chisqr.test function:

> chisq.test(data, correct = FALSE)

    Pearson's Chi-squared test

data:  data
X-squared = 6.3791, df = 1, p-value = 0.01155

The $\chi^2$ value produced by R is a bit different from what we computed by hand due to rounding error in the latter case. But the results are very close and the decision regarding the null hypothesis is reproduced correctly.